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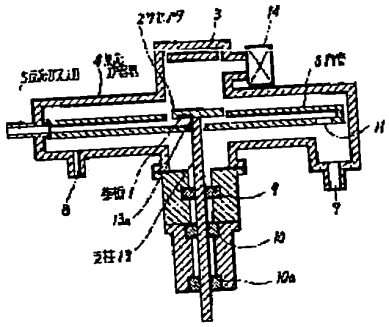
(54) VAPOR PHASE GROWTH APPARATUS

(57)Abstract:
PURPOSE: To form a uniform film on the surface of a film forming substrate by a vapor phase growth apparatus to which a susceptor in which the film forming substrate is incorporated is attached movably vertically and in which the susceptor is heated to form the film by a method wherein the susceptor is supported from below.



CONSTITUTION: A film forming substrate 1 is attached to a susceptor 2 which is supported from below by a vertically movable pillar 13 at its center part. The film forming substrate 1 and the susceptor 2 are heated by a heater 3 and, while a pillar 13 is at an elevated position, the film forming substrate 1 is replaced through a gate valve 14. Or, after the susceptor 2 on which a substrate on which a film is not formed is placed onto the upper part of the pillar 13, the susceptor 2 is made to descend to a required position to form a film. By this constitution, the pillar 13 can be driven to rotate around a shaft while the airtightness of a reaction chamber 4 is maintained, so that the thickness of the film formed on the substrate can be uniform.

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CLAIMS

[Claim(s)]

[Claim 1] It introduces from the reactant gas entrance in which reactant gas was prepared by the end of a reactor container. The inside of the inner tube which was installed in the interior of a reactor container and which has rectangular cross-section passage mostly is passed mostly horizontally. In the vapor-growth equipment which forms membranes to the aforementioned substrate formed membranes by attaching possible [vertical movement of the susceptor which included the substrate which makes an inferior surface of tongue the field formed membranes formed membranes in opening prepared in the middle of the passage of the aforementioned inner tube], and heating a susceptor Vapor-growth equipment characterized by supporting a susceptor from a lower part.

[Claim 2] Vapor-growth equipment characterized by the support means which support a susceptor from a lower part serving as a vertical-movement means to carry out vertical movement of the susceptor in equipment given in the 1st term of a claim.

[Claim 3] Vapor-growth equipment with which the support means which support a susceptor from a lower part are characterized by supporting a susceptor in the core of a susceptor in equipment given in the 1st term of a claim.

[Claim 4] Vapor-growth equipment with which the support means which support a susceptor from a lower part are characterized by supporting a susceptor in the periphery section of a susceptor in equipment given in a claim 1st.

[Claim 5] Vapor-growth equipment characterized by making into a support or a support plate the support means which support a susceptor from a lower part in equipment given in the 1st term of a claim, the 2nd term, the 3rd term, or the 4th term.

[Claim 6] Vapor-growth equipment with which a support is characterized by having two or more branches prolonged from a support in the upper-limit section in a field perpendicular to a plate or shafts, such as a disk perpendicular to a shaft, as a supporter of a susceptor by support means consisting of one support in equipment given in the 5th term of a claim when using support means as a support.

[Claim 7] Vapor-growth equipment characterized by making the depth of this crevice in agreement with the thickness of a supporter while forming the crevice which inserts the supporter of a support in the inferior-surface-of-tongue side of a susceptor in equipment given in the 6th term of a claim.

[Claim 8] Vapor-growth equipment characterized by forming a support possible [the circumference rotation drive of a shaft] in equipment given in the 6th term of a claim, or the 7th term.

[Claim 9] The support portion located in the thickness of the rectangular cross-section passage which an inner tube constitutes in equipment given in the 6th term of a claim, the 7th term, or an octavus term is vapor-growth equipment characterized by setting maximum of the diameter size in a horizontal section to 25mm or less in any height position.

[Claim 10] Vapor-growth equipment characterized by performing support of a susceptor on the side of a support plate by making the field of a support plate into the perpendicular direction in equipment given in the 5th term of a claim when making support means into a support plate.

[Claim 11] The support means which support a susceptor in equipment given in the 3rd term of a claim in the core of a susceptor are vapor-growth equipment characterized by incorporating the sensor for temperature controls near the susceptor center of a susceptor side point.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention attaches almost horizontally the substrate of disc-like or a square shape tabular formed membranes in a vertical move row on the susceptor which can rotate for the organic-metal vapor-growth equipment which mainly grows up a compound semiconductor film into the substrate formed membranes, heats a susceptor by the heating means installed above the susceptor, and relates to the vapor-growth equipment which horizontal shell reactant gas is introduced [equipment] and grows up a predetermined film on the substrate formed membranes.
[0002]
[Description of the Prior Art] The conventional example of composition of this kind of organic-metal vapor-growth equipment is shown in drawing 6 . This drawing (a) shows the longitudinal section of this equipment, and the susceptor 2 is equipped with the substrate 1 formed membranes. Near the susceptor 2, the substrate 1 and the heater 3 for susceptor 2 heating are arranged. Reactant gas enters from the reactant gas entrance 5 established in the edge of the reaction container 4, and the inside of the inner tube 6 currently installed in the interior of the reaction container 4 is led to it under the substrate 1 formed membranes. It is decomposed thermally by the susceptor 2 and the substrate 1 formed membranes which were heated at the heater 3, and reactant gas is diffused, reaches to the substrate 1 formed membranes, and forms a film. The gas which passed through the bottom of the substrate 1 formed membranes is discharged from the gas exhaust port 7.
[0003] The hydrogen gas (or nitrogen gas or inert gas) led to the space between the reactor container 4 and an inner tube 6 from the sweep gas entrance 8 was poured, and leakage **** of the reactant gas to this space is prevented. This drawing (b) shows the flat-surface cross section of this equipment. The reactant gas introduced from the reactant gas entrance 5 is seen from the upper surface formed in the upper section of an inner tube 6, becomes a broad laminar flow in the triangle-like breadth section, and flows down to the substrate 1 with which the susceptor 2 was equipped formed membranes. The gas which passed through the bottom of the substrate 1 formed membranes is discharged out of a reactor 4 from the gas exhaust port 7 installed in the downstream.
[0004] The susceptor base 12 can move up and down by the susceptor driving shaft 13 combined with the mechanism which is not illustrated. The substrate 1 formed membranes is exchangeable by taking a susceptor 2 through a gate valve 14 with the conveyance mechanism in the load lock chamber which does not show the susceptor base 12 in drawing in the state where it pulled up upwards. Moreover, a susceptor can also be rotated in order to raise the membranous homogeneity for substrate wearing for forming membranes simultaneously to two or more substrates.
[0005] As shown in drawing 6 , there are no faults, such as fall of the dust to a membrane formation side like [in the case of having arranged the susceptor 2 and the substrate 1 formed membranes in the lower part of an inner tube 6 with the equipment arranged in the upper part of an inner tube 6].
[0006]
[Problem(s) to be Solved by the Invention] It is important to turn the membrane formation side

of the substrate formed membranes caudad in the above equipments, to make it expose in an inner tube, and to make it the laminar flow of reactant gas hit a membrane formation side, therefore it must consider the method of equipping with the susceptor of the substrate formed membranes, and the maintenance method of a susceptor. Although it is the method of placing the susceptor equipped with the substrate as the inferior surface of tongue of a flange rides on the hole which the easiest method of susceptor maintenance formed the flange in the upper surface side of a susceptor, and was established in the inner-tube upper part, exchange of the susceptor which equipped with the substrate or the substrate in that case is difficult. Therefore, usually it considers as the mechanism in which the susceptor equipped with the substrate is held from the upper part, and can generally be automatically exchanged because of exchange of a substrate. Moreover, in order to make uniform that heat capacity is small in order to heat at a heater, and temperature distribution, as for a susceptor, it is desirable for there to be neither a difference of near and thickness nor a salient as monotonously as possible. And the device for not disturbing the laminar flow of a formed membranes substrate front face as much as possible as mentioned above is required. In order to make it not disturb the laminar flow of such reactant gas that holds a near susceptor from the upper part monotonously, and moreover passes along the bottom of a susceptor, the elaborate susceptor maintenance mechanism in which the side or the upper surface of a susceptor is held was required. And since a susceptor is heated by membrane formation temperature, a susceptor maintenance mechanism is also heated by the temperature near it, and the material is limited extremely. Considering delivery with the load lock chamber of the susceptor equipped with the substrate formed membranes, furthermore, the positioning mechanism of a susceptor is also needed for exchange of the substrate formed membranes.

[0007] Thus, it leads to it being very difficult to constitute a complicated minute mechanism from material to which it was moreover restricted, and it becoming the cause which makes reliability of equipment low, and raising the price of equipment. The purpose of this invention is offering the vapor-growth equipment which holds a susceptor so that thickness or a membraneous uniform film may be formed in the membrane formation side of the substrate formed membranes to which the membrane formation side's was turned caudad, without using a complicated minute mechanism.

[0008]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, it sets to this invention. It introduces from the reactant gas entrance in which reactant gas was prepared by the end of a reactor container. The inside of the inner tube which was installed in the interior of a reactor container and which has rectangular cross-section passage mostly is passed mostly horizontally. It attaches possible [vertical movement of the susceptor which included the substrate which makes an inferior surface of tongue the field formed membranes formed membranes in opening prepared in the middle of the passage of the aforementioned inner tube], and the vapor-growth equipment which forms membranes to the aforementioned substrate formed membranes is constituted by heating a susceptor to the equipment which supports a susceptor from a lower part.

[0009] Here, if the support means which support a susceptor from a lower part serve as a vertical-movement means to carry out vertical movement of the susceptor, they are suitable. Moreover, from the equipment function which you want to demonstrate, the support means which support a susceptor from a lower part shall support a susceptor in the core of a susceptor, or shall perform it in the periphery section.

[0010] Moreover, it is very suitable if the support means which support a susceptor from a lower part are made into a support or a support plate. And it is very suitable if it should have two or more branches to which support means consist of one support, and a support extends from a support in the upper-limit section in a field perpendicular to a plate or shafts, such as a disk perpendicular to a shaft, as a supporter of a susceptor when using support means as a support.

[0011] And while forming the crevice which inserts the supporter of a support in the inferior-surface-of-tongue side of a susceptor in this case, it is good to make it make the depth of this

crevice in agreement with the thickness of a supporter. Moreover, it is very suitable if it forms possible [the circumference rotation drive of a shaft of a support] in using support means as a support.

[0012] In addition, when using support means as a support, as for the support portion located in the thickness of the rectangular cross-section passage which an inner tube constitutes, it is good in any height position to set maximum of the diameter size in a horizontal section to 25mm or less. Moreover, it is very suitable if it is made to perform support of a susceptor on the side of a support plate by making the field of a support plate into the perpendicular direction when making support means into a support plate.

[0013] Moreover, the support means which support a susceptor in the core of a susceptor are very suitable if the sensor for temperature controls should be incorporated near the susceptor center of a susceptor side point.

[0014]

[Function] Thus, if a susceptor is supported from a lower part, the complicated mechanism in which resist gravity and a susceptor is held in the chinning-exercises state becomes unnecessary, and the maintenance mechanism of a susceptor can be formed very simply. And since it is easily possible to make it not disturb the laminar flow of reactant gas by taking into consideration the configuration, a number, and arrangement, the support means for supporting the weight of a susceptor can realize vapor-growth equipment equipped with the good membrane formation performance with simple structure.

[0015] Then, if the support means which support a susceptor from a lower part serve as a vertical-movement means to carry out vertical movement of the susceptor, it will become unnecessary to establish the vertical-movement mechanism of a susceptor independently, and exchange of the substrate formed membranes will be attained by the simple equipment configuration. Moreover, as support means which support a susceptor from a lower part, since area becomes large, the thing which supports a susceptor in the core of a susceptor, then the susceptor front face of the circumference of a core can equip with two or more substrates, and can form the substrate of these plurality simultaneously, and its productivity of equipment improves. Moreover, it also becomes possible easily to rotate a susceptor and it becomes easy the thickness of the film formed and membraneous to equalize it.

[0016] Moreover, as support means which support a susceptor from a lower part, it becomes possible easily, the slight disorder of a laminar flow is also prevented by this, and the thing which supports a susceptor in the periphery section of a susceptor, then the parallel maintenance which holds a susceptor front face in parallel strictly on the base of rectangular cross-section passage can obtain a good film. Furthermore, a susceptor front face can be leaned to the flow of reactant gas, and the inclination maintenance which changes the rate of flow of reactant gas by the susceptor upstream and the downstream, and the ununiformity of thickness which may happen when it becomes possible easily and the reactant gas component on the front face of a susceptor changes by the susceptor upstream and the downstream can compensate this easily.

[0017] In addition, in this way, in being made to support a susceptor in the periphery section of a susceptor, it also becomes possible to consider as the structure of transmitting the force of a hoop direction for support means to the periphery section of a susceptor, and rotating a susceptor. In this case, while using material with small coefficient of friction for the sliding side of the support means which support a susceptor, use the torque generating means of for example, a watthour-meter formula for transmitting the force of a hoop direction, and as support means are made to support this, it is made to transmit the force of a hoop direction to non-contact, and the stability of rotation operation and reinforcement of stable rotation operation are attained. By doing in this way, both the effects of the effect of main support and the effect of periphery section support can be acquired simultaneously.

[0018] Then, a support or a support plate, then a member required for support of a susceptor can be made into the thing of a low cost, and cost required for support reduces the support means which support a susceptor from a lower part. Then, by support means consisting of one support, when using support means as a support, if the support should equip the upper-limit

section with two or more branches prolonged from a support in a field perpendicular to a plate or shafts, such as a disk perpendicular to a shaft, as a supporter of a susceptor, in it Since support of a susceptor comes to be performed at a flat surface with a breadth, it becomes possible easily to support in parallel with the flow of gas and to make it not disturb a laminar flow, and realization of a good membrane formation property becomes easy.
[0019] and in this way, in preparing a plate and two or more branches in the point of a support as a supporter While forming the crevice which inserts the supporter of a support in the inferior-surface-of-tongue side of a susceptor Since the concavo-convex section does not arise in the inferior-surface-of-tongue side of a susceptor but the inferior-surface-of-tongue side of a susceptor becomes flat by making it make the depth of this crevice in agreement with the thickness of a supporter, disorder of a laminar flow stops arising, and good membraneous quality can be obtained.
[0020] Moreover, if it forms possible [the circumference rotation drive of a shaft of a support], the rotation drive of the susceptor can be carried out at the time of membrane formation, and equalization of the thickness on each substrate with which the susceptor was equipped, and equalization of the thickness between substrates can be attained easily. And when using support means as a support, the support portion located in the thickness of the rectangular cross-section passage which an inner tube constitutes can give intensity required for weight support or a rotation drive of a susceptor in any height position, securing the substrate wearing field which does not receive the influence of a turbulent flow in a susceptor front face to sufficient size, if it is made to set maximum of the diameter size in a horizontal section to 25mm or less.
[0021] Moreover, if support means are made into a support plate and it is made to support a susceptor on the side of a support plate by making a plate surface into the perpendicular direction Since disorder of a laminar flow stops arising even if it places a support plate into a flow by making a plate surface into a flow at parallel, and giving suitably the horizontal section configuration of the upstream edge of a plate surface, and a downstream edge When it is not necessary to rotate a susceptor, a support plate is used the number of sheets according to the size of a susceptor, and the weight, a susceptor can be supported easily and a good film can be obtained.
[0022] Moreover, as compared with the conventional equipment with which the temperature-control sensor was built into the thing [into which the sensor for temperature controls was built near the susceptor center of a susceptor side point], then rear-face side of a susceptor, a temperature-control sensor becomes near by the substrate, the detection precision of substrate temperature goes up, and it becomes easy membraneous to control the support means which support a susceptor in the core of a susceptor.
[0023]
[Example] The 1st example of the vapor-growth equipment configuration by this invention is shown in drawing 1 . This example shows the case where the support means which support a susceptor from a lower part are used as a support. The sign in drawing makes it have corresponded with the thing with the same operation in drawing 6 . Moreover, drawing is what showed only the important section concerning this invention like drawing 6 , and the flueing means after a part for a material gas controller and the stage of the preceding paragraph etc. is omitted from the reactor. The reactant gas supplied from the reactant gas entrance 5 established in the end of the reactor container 4 is led to under the substrate 1 formed membranes by the inner tube 6 for flow composition. A susceptor 2 is equipped with the substrate 1 formed membranes, and it supports the susceptor 2 with the support 13 which can move up and down from a lower part in the core. The heater 3 is installed above the susceptor 2 and the substrate 1 formed membranes and a susceptor 3 can be heated.
[0024] In order to exchange the substrate formed membranes, the gate valve 14 connected with the load lock chamber which built in the conveyance mechanism for conveying the susceptor equipped with the substrate formed membranes or the substrate formed membranes, and which is not illustrated is formed in the upper part side of the reactor container 4. Membranes are formed by descending, after receiving the susceptor which

exchanged the substrate formed membranes through the gate valve 14, or equipped with the substrate non-formed membranes after the support 13 had gone up in the upper part of a support 13, and moving to a position. The inferior surface of tongue of the substrate which is a membrane formation side is mostly on the extended field on the upper surface of internal of the inner tube of an upstream, and the bottom of a substrate is made to flow in a membrane formation position, without the laminar flow of reactant gas producing disorder.

[0025] Thus, it becomes possible to hold the airtight in the reactor container 4 and to carry out the rotation drive of the support at the circumference of a shaft, when support means are used as a support and a pillar or a periphery uses as a circular hollow shaft the equipment configuration which supports a susceptor with this support at the center, then a support, and it becomes easy it to equalize from the exterior, the thickness of the film formed in a substrate, since it becomes possible easily to rotate a susceptor by this. Moreover, it is avoidable that equipment complicates the lead wire which results a support in a temperature-control sensor when a temperature-control sensor is built into a hollow shaft, then a point for a temperature-control sensor since it can let the interior of a hollow shaft pass.

[0026] The 2nd example of susceptor support means is shown in drawing 2 . A susceptor is not rotated and this example shows an example of suitable support means to make influence of the laminar-flow state on support means further smaller than the case where it is drawing 1 . Support means have prepared 13d of grasping sections in the prism upper-limit section, using a prism 13 as a support. 13d of grasping sections is formed in the shape of a KO character, and they grasp the downstream periphery section of a susceptor 2 between two sides of opposite of a KO character. Since 13d of grasping sections is located in the lowest style side of a susceptor, it is also possible for there to be no influence of 13d of grasping sections to the laminar flow in an upstream substrate position, therefore to make a prism 13 into two or more with the size and weight of a susceptor.

[0027] Drawing 3 shows the 3rd example of susceptor support means. It is made for support means to support the periphery section of a susceptor 2 on two both sides by the side of a board by making a plate surface into the perpendicular direction, using this two sheets as a support plate. In this manner of support, although located in a gas stream, a laminar-flow state will not be disturbed in respect of a substrate, and about two susceptor of a support plate 13 will not produce a membraneous fall, if the support plate 13 is separated from the substrate enough. Moreover, if such manner of support is taken, the parallel support which supports a susceptor in parallel with the flow of reactant gas will be attained easily, and ** which also prevents slight disorder generating of the laminar-flow state in a substrate field at least will be made. Moreover, in this manner of support, when inclination support of a susceptor also becomes possible easily and leans and supports a susceptor 2 to a flow, the rate of flow is changed by the upstream and downstream of a susceptor 2, and the thickness ununiformity which may be produced when there is change of a reactant gas component by the upstream and downstream on the front face of a substrate can also be compensated easily, and can be equalized.

[0028] Furthermore, especially in this manner of support, although not illustrated, rotation of a susceptor 2 can also be enabled. As a mechanism for transmitting the force of a hoop direction to the susceptor periphery section, for example, by allotting the torque generating means of a watthour-meter formula to the susceptor periphery section, and supporting this by the support plate 13 Since there is no fear of raising dust like [in the case of being able to transmit the force of a hoop direction to non-contact at the susceptor periphery section, and transmitting the force of a hoop direction mechanically] and there is no friction There is also no aging of the hoop-direction force transmitted, and rotation operation by which the susceptor was stabilized, and the reinforcement of stable rotation operation become possible. And since maintenance of the laminar-flow state in this case can prepare a susceptor front face and the pole face which counters from a susceptor front face from the generating principle of the hoop-direction force at the required interval which ******(ed), it is possible satisfactory. In addition, in this manner of support, since the back face of a support plate turns into a sliding side, coefficient of friction is small and it carries out to the quality of the material

with few amounts of raising dust, for example, the field which was being worn with 4 fluoridation ethylene.

[0029] The 4th example of susceptor support means is shown in drawing 4 . As stated previously, it is very important for the membrane formation side of a substrate to pass reactant gas smoothly. It is required for ** which maintained the surface of revolution of a susceptor at the flat surface when rotating especially a susceptor to attach a susceptor in a support right-angled. Therefore, the way the device for keeping the bond part of a susceptor and a support right-angled prepares disk 13b with a diameter of about 20mm in the crowning of a support 13 like this example, on the other hand, establishes the crevice of this and the form where it corresponds in a susceptor 2, and entraps these both required is effective. Of course, if not only a disk but the configuration of a board is monotonous, it is good anything also at a polygon.

[0030] Drawing 5 shows the modification of the example shown in drawing 4 , and as shown in drawing, if it considers as the structure which lengthened two or more branches 13c within the same flat surface as disk 13b to 13b of the crowning of the support 13 shown in drawing 4 , an effect is in stabilization of a susceptor still further.

[0031]

[Effect of the invention] In this invention, since vapor-growth equipment was considered as above-mentioned composition, the effect indicated below is acquired. With the equipment of a claim 1, since the substrate formed membranes supported the susceptor with which an inferior-surface-of-tongue side is equipped from the lower part, although a susceptor is held, a complicated minute maintenance mechanism like before becomes unnecessary, the maintenance mechanism of a susceptor can be constituted very simply, and the reliability of equipment increases in it.

[0032] With the equipment of a claim 2, it becomes unnecessary to establish the vertical-movement mechanism of a susceptor independently, and exchange of the substrate formed membranes is attained by the simple equipment configuration, and it becomes easy to use equipment as the equipment suitable for unattended operation, and the automated equipment can be obtained cheaply. With the equipment of a claim 3, since a latus substrate wearing field is securable for a susceptor front face, it equips with two or more substrates, simultaneous processing becomes possible, and the productivity of equipment improves.

[0033] With the equipment of a claim 4, the parallel maintenance which holds a susceptor in parallel with the flow of reactant gas, or the inclination maintenance leaned and held to the flow of reactant gas becomes easy, and it becomes easy to obtain good membraneous quality and a thickness distribution. Moreover, both the effects of the effect of main support and the effect of periphery section support which were mentioned above can be simultaneously acquired by constituting possible [rotation of support means of a susceptor].

[0034] With the equipment of a claim 5, since a member required for support of a susceptor serves as a low cost and a maintenance mechanism is also simplified, cost required for support decreases compared with the conventional supporting structure. With the equipment of a claim 6, since it has as a supporter the flat surface to which the support which supports a susceptor had a breadth in the point, it becomes possible easily to support a susceptor so that a laminar-flow state may not be disturbed, and the repeatability of a membrane formation performance can obtain as equipment the membraneous film which was good and was excellent.

[0035] With the equipment of a claim 7, since the inferior-surface-of-tongue side of a susceptor becomes flat, disorder does not arise in the laminar flow by the side of the inferior surface of tongue of a susceptor, but good membraneous quality can be obtained. With the equipment of a claim 8, since a support is formed possible [the circumference rotation drive of a shaft], a susceptor can be rotated through a support and achievement of thickness equalization on each substrate and equalization of the thickness between substrates becomes easy by this.

[0036] With the equipment of a claim 9, since the support portion in the flow of reactant gas was thinly formed in any of the height position in the range which the maximum diameter size

of 25mm or less in a horizontal section and the desired strength of a support can maintain, the substrate wearing field which is not influenced of a turbulent flow can be secured widely, and the number of sheets with which it can be equipped [of a substrate] simultaneous can use increase and equipment as the high equipment of productivity.

[0037] Since the side of a support plate was made to perform support of a susceptor by making the field of a support plate into the perpendicular direction with the equipment of a claim 10 when making support means into a support plate By giving suitably the horizontal section configuration of the upstream edge and downstream edge as parallel to a flow in a support plate, when it is not necessary to rotate a susceptor A good film can be obtained disorder stopping arising in a laminar flow, and this using a support plate for it the number of sheets according to the size of a susceptor, and the weight, and supporting a susceptor easily, even if a support plate is in a gas stream.

[0038] With the equipment of a claim 11, since a temperature-control sensor is incorporated near the susceptor center of a support-means point, the position of a temperature-control sensor becomes close to a substrate compared with the former, the detection precision of substrate temperature goes up, membraneous control becomes easy, and it becomes possible easily to obtain a good film.

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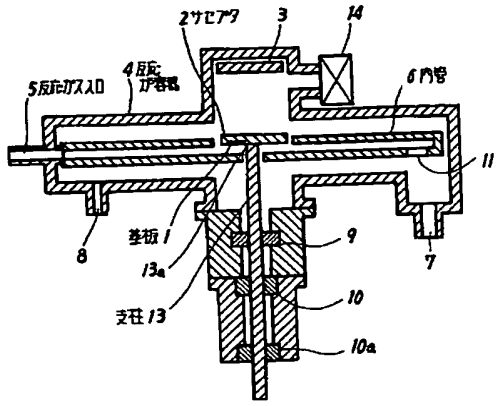
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing of longitudinal section showing the 1st example of the vapor-growth equipment configuration by this invention
[Drawing 2] The perspective diagram showing an example of different structure from drawing 1 of the susceptor support means by this invention as the 2nd example of susceptor support means
[Drawing 3] The perspective diagram showing the 3rd example of the susceptor support means by this invention
[Drawing 4] The cross section showing the 4th example of the susceptor support means by this invention
[Drawing 5] The susceptor bottom view showing the modification of the susceptor support-means example shown in drawing 4
[Drawing 6] It is drawing showing the example of composition of conventional vapor-growth equipment, and for this drawing (a), it is drawing of longitudinal section and this drawing (b) is a cross-sectional view.
[Description of Notations]
1 Substrate Formed Membranes (Substrate)
2 Susceptor
4 Reactor Container
5 Reactant Gas Entrance
6 Inner Tube
13 Support Means (Support, Support Plate)
13b Disk
13d Branch
15 Reactant Gas

[Translation done.]

Drawing selection [Representative drawing]



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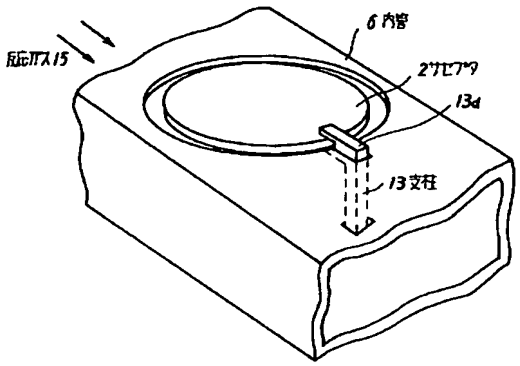

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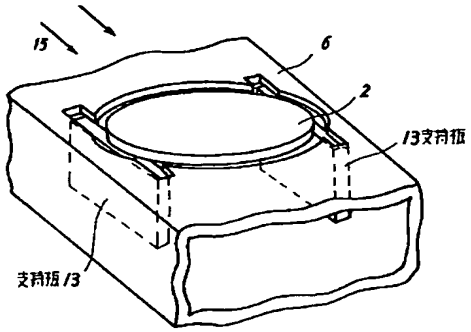

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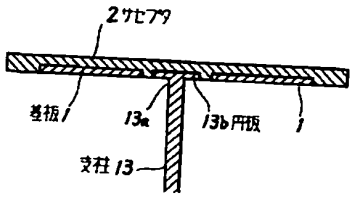

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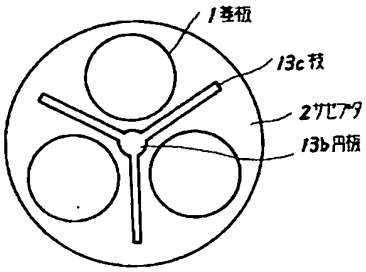

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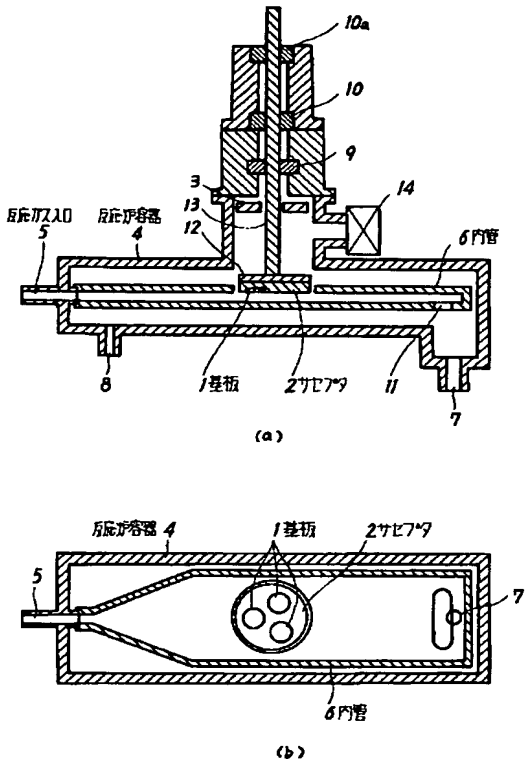

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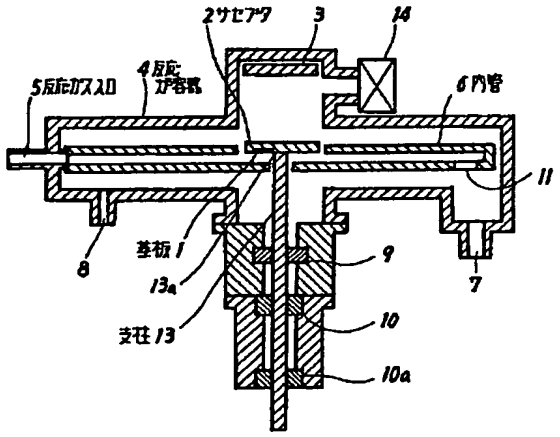
(54)【発明の名称】　気相成長装置

(57)【要約】

【目的】反応ガスを水平に流すＭＯＣＶＤ用気相成長装置において、成膜面への粉塵汚染防止のために下面側に基板を装着するサセプタを、簡易に、かつ反応ガスの流れを乱さないように保持することのできる装置構成を提供する。

【構成】サセプタ２を下方から支える装置とする。この場合、装置構成の簡易化のため、支持手段に上下動手段を兼ねさせ、装置の生産性向上のため、サセプタ２を中心部で支持させ基板１の装着可能領域を広くして複数基板の同時処理を可能にし、膜質向上のため、サセプタ２を周辺部で支持させて流れに対するサセプタの平行保持，傾斜保持を容易にし、支持手段は支柱１３または支持板としてサセプタ保持機構を低コスト化し、支持手段を支柱とするときには上端面に支持面を設けてサセプタの流れに対する平行保持を容易にし、あるいは回転駆動を可能として膜質，膜厚均一性向上を容易にし、さらには径を細くして装置の低コスト化，生産性向上を図る。



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【特許請求の範囲】

【請求項1】反応ガスを反応炉容器の一端に設けられた反応ガス入口から導入し、反応炉容器内部に設置したほぼ方形断面流路をもつ内管内をほぼ水平方向に流し、前記内管の流路途中に設けた開口部に、下面を被成膜面とする被成膜基板を組み込んだサセプタを上下移動可能に取り付け、サセプタを加熱することにより前記被成膜基板に成膜を行う気相成長装置において、サセプタを下方から支持することを特徴とする気相成長装置。

【請求項2】請求項第1項に記載の装置において、サセプタを下方から支持する支持手段が、サセプタを上下移動させる上下動手段を兼ねることを特徴とする気相成長装置。

【請求項3】請求項第1項に記載の装置において、サセプタを下方から支持する支持手段が、サセプタをサセプタの中心部で支持することを特徴とする気相成長装置。

【請求項4】請求項第1に記載の装置において、サセプタを下方から支持する支持手段が、サセプタをサセプタの周縁部で支持することを特徴とする気相成長装置。

【請求項5】請求項第1項，第2項，第3項または第4項に記載の装置において、サセプタを下方から支持する支持手段を支柱または支持板とすることを特徴とする気相成長装置。

【請求項6】請求項第5項に記載の装置において、支持手段を支柱とするときに、支持手段が1本の支柱からなりかつ、支柱が、上端部に、軸に垂直な円板等の平板もしくは軸に垂直な面内で支柱から延びる複数の枝をサセプタの支持部として備えることを特徴とする気相成長装置。

【請求項7】請求項第6項に記載の装置において、サセプタの下面側に支柱の支持部を嵌め合わせる凹部を形成するとともに、該凹部の深さを支持部の厚みと一致させることを特徴とする気相成長装置。

【請求項8】請求項第6項または第7項に記載の装置において、支柱を軸まわり回転駆動可能に形成することを特徴とする気相成長装置。

【請求項9】請求項第6項，第7項または第8項に記載の装置において、内管が構成する方形断面流路の厚み内に位置する支柱部分は、いずれの高さ位置でも、水平断面における差渡し寸法の最大値を25mm以下とすることを特徴とする気相成長装置。

【請求項10】請求項第5項に記載の装置において、支持手段を支持板とするときに、サセプタの支持を、支持板の面を鉛直方向として支持板の側面で行うようにすることを特徴とする気相成長装置。

【請求項11】請求項第3項に記載の装置において、サセプタをサセプタの中心部で支持する支持手段は、サセプタ側先端部のサセプタ中心近傍に温度制御用センサが組み込まれることを特徴とする気相成長装置。

【発明の詳細な説明】

2

【0001】

【産業上の利用分野】この発明は、主に化合物半導体膜を被成膜基板に成長させる有機金属気相成長装置を対象としたものであり、上下移動ならびに回転が可能なサセプタ上に円板状または角型板状の被成膜基板をほぼ水平に取り付け、サセプタの上方に設置した加熱手段によりサセプタを加熱し、水平方向から反応ガスを導入して被成膜基板上に所定の膜を成長させる気相成長装置に関する。

【0002】

【従来の技術】図6にこの種の有機金属気相成長装置の従来の構成例を示す。同図（a）はこの装置の縦断面を示すもので、被成膜基板1はサセプタ2に装着されている。サセプタ2の近傍には基板1およびサセプタ2加熱用のヒータ3が配置されている。反応ガスは反応容器4の端部に設けられた反応ガス入口5から入り、反応容器4の内部に設置されている内管6の中を被成膜基板1の下へと導かれる。反応ガスはヒータ3で加熱されたサセプタ2および被成膜基板1で加熱・分解され、拡散して被成膜基板1へ到達し膜を形成する。被成膜基板1の下を通過したガスはガス排出口7から排出される。

【0003】反応炉容器4と内管6との間の空間にはスイープガス入口8から導かれた水素ガス（または窒素ガスあるいは不活性ガス）が流され、この空間への反応ガスの漏れ出しを防止している。同図（b）は、同装置の平面断面を示したものである。反応ガス入口5から導入された反応ガスは、内管6の上流部に形成された上面より見て三角形状の広がり部で幅広の層流になり、サセプタ2に装着された被成膜基板1の下へと流れる。被成膜基板1の下を通過したガスは下流側に設置されたガス排出口7から反応炉4の外へ排出される。

【0004】サセプタ台12は、図示されていない機構と結合されたサセプタ駆動軸13により上下動できる。サセプタ台12を上方へ引き上げた状態で図に示していないロードロック室内の搬送機構により、ゲートバルブ14を通してサセプタ2を出し入れすることにより被成膜基板1の交換を行うことができる。また、複数枚の基板に同時に成膜するための基板装着のため、あるいは膜の均一性を向上させる目的でサセプタを回転することもできる。

【0005】図6に示したように、サセプタ2および被成膜基板1を内管6の上部に配置した装置では、内管6の下部に配置した場合のような成膜面への粉塵の落下等の欠点が無い。

【0006】

【発明が解決しようとする課題】上記のような装置においては被成膜基板の成膜面を下方に向けて内管内に露出させ成膜面に反応ガスの層流が当たるようにすることが重要であり、そのため被成膜基板のサセプタへの装着法、サセプタの保持方法を考えなければならない。サセ

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プタ保持の最も簡単な方法はサセプタの上面側にフランジを形成し、内管上部に設けた穴の上にフランジの下面が乗るように基板を装着したサセプタを置く方法であるが、その場合は基板あるいは基板を装着したサセプタの交換が難しい。従って一般には、基板の交換のために基板を装着したサセプタを上方から保持して自動的に交換できる機構とするのが普通である。また、サセプタはヒータで加熱するために熱容量が小さいこと、温度分布を均一にするためにできるだけ平板に近く、内圧の差や突起等が無いことが望ましい。しかも前記のように被成膜基板表面の層流をできるだけ乱さないための工夫が必要である。このような平板に近いサセプタを上方から保持し、しかもサセプタの下を通る反応ガスの層流を乱さないようにするには、サセプタの側面または上面を掴むような精巧なサセプタ保持機構が必要であった。しかもサセプタは成膜温度に加熱されるのでサセプタ保持機構もそれに近い温度に加熱され、その材料は極めて限定される。さらに被成膜基板の交換のため、被成膜基板を装着したサセプタのロードロック室との受け渡しを考えるとサセプタの位置決め機構も必要になる。

【０００７】このように複雑精緻な機構をしかも限られた材料で構成することは非常に困難で、装置の信頼性を低くする原因になり、また装置の価格を高めることにつながる。本発明の目的は、複雑精緻な機構を用いることなく、成膜面を下方に向けた被成膜基板の成膜面に膜厚あるいは膜質の均一な膜が形成されるようにサセプタを保持する気相成長装置を提供することである。

【０００８】

【課題を解決するための手段】上記課題を解決するために、本発明においては、反応ガスを反応炉容器の一端に設けられた反応ガス入口から導入し、反応炉容器内部に設置したほぼ方形断面流路をもつ内管内をほぼ水平方向に流し、前記内管の流路途中に設けた開口部に、下面を被成膜面とする被成膜基板を組み込んだサセプタを上下移動可能に取り付け、サセプタを加熱することにより前記被成膜基板に成膜を行う気相成長装置を、サセプタを下方から支持する装置に構成する。

【０００９】ここで、サセプタを下方から支持する支持手段が、サセプタを上下移動させる上下動手段を兼ねるようにすれば好適である。また、サセプタを下方から支持する支持手段は、発揮させたい装置機能より、サセプタの支持をサセプタの中心部で行うものとするか、周縁部で行うものとする。

【００１０】また、サセプタを下方から支持する支持手段を支柱または支持板とすれば極めて好適である。そして、支持手段を支柱とするときに、支持手段が１本の支柱からなりかつ、支柱が、上端部に、軸に垂直な円板等の平板もしくは軸に垂直な面内で支柱から延びる複数の枝をサセプタの支持部として備えたものとすれば極めて好適である。

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【００１１】そして、この場合には、サセプタの下面側に支柱の支持部を嵌め合わせる凹部を形成するとともに、該凹部の深さを支持部の厚みと一致させるようにするのがよい。また、支持手段を支柱とする場合には、支柱を軸まわり回転駆動可能に形成すれば極めて好適である。

【００１２】なお、支持手段を支柱とする場合には、内管が構成する方形断面流路の厚み内に位置する支柱部分は、いずれの高さ位置でも、水平断面における差渡し寸法の最大値を２５mm以下とするとよい。また、支持手段を支持板とするときに、サセプタの支持を、支持板の面を鉛直方向として支持板の側面で行うようにすれば極めて好適である。

【００１３】また、サセプタをサセプタの中心部で支持する支持手段は、サセプタ両先端部のサセプタ中心近傍に温度制御用センサが組み込まれたものとすれば極めて好適である。

【００１４】

【作用】このように、サセプタを下方から支持するようにすれば、重力に抗してサセプタを懸垂状態に保持する複雑な機構が不必要となり、サセプタの保持機構を極めて簡易に形成することができる。そして、サセプタの重量を支えるための支持手段は、その形状，数および配置を考慮することにより、反応ガスの層流を乱さないようにすることは容易に可能であるので、良好な成膜性能を備えた気相成長装置を簡易な構造で実現することができる。

【００１５】そこで、サセプタを下方から支持する支持手段が、サセプタを上下移動させる上下動手段を兼ねるようにすれば、サセプタの上下動機構を別に設ける必要がなくなり、簡易な装置構成で被成膜基板の交換が可能になる。また、サセプタを下方から支持する支持手段として、サセプタの支持をサセプタの中心部で行うものとすれば、中心部まわりのサセプタ表面は面積が広くなるので、複数の基板を装着してこれら複数の基板を同時に成膜することができ、装置の生産性が向上する。また、サセプタを回転させることも容易に可能になり、成膜される膜の膜厚，膜質の均一化が容易となる。

【００１６】また、サセプタを下方から支持する支持手段として、サセプタの支持をサセプタの周縁部で行うものとすれば、サセプタ表面を方形断面流路の底面に厳密に平行に保持する平行保持が容易に可能となり、これにより層流のわずかな乱れも防止され、良質な膜を得ることができる。さらに、サセプタ表面を反応ガスの流れに対して傾け、サセプタ上流側と下流側とで反応ガスの流速を変える傾斜保持も容易に可能となり、サセプタ上流側と下流側とでサセプタ表面での反応ガス成分が変化した場合に起こりうる膜厚の不均一も容易にこれを補償することができる。

【００１７】なお、このように、サセプタの支持をサセ

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プタの周縁部で行うようにする場合には、支持手段を、サセプタの周縁部に周方向の力を伝達してサセプタを回転させる構造とすることも可能になる。この場合には、サセプタを支持する支持手段の滑動面に摩擦係数の小さい材料を用いるとともに、周方向の力を伝達するのに例えば電力量計式のトルク発生手段を用い、これを支持手段に担持させるようにして周方向の力を非接触に伝達するようにし、回転動作の安定性と、安定した回転動作の長寿命化を図るようにする。このようにすることにより、中心支持の効果と周縁部支持の効果との両効果を同時に得ることができる。

【００１８】そこで、サセプタを下方から支持する支持手段を支柱または支持板とすれば、サセプタの支持に必要な部材を低コストのものとすることができ、支持に必要なコストが低減する。そこで、支持手段を支柱とするときに、支持手段が１本の支柱からなりかつ、支柱が、上端部に、軸に垂直な円板等の平板もしくは軸に垂直な面内で支柱から延びる複数の枝をサセプタの支持部として備えたものとすれば、サセプタの支持が広がりのある平面で行われるようになるので、ガスの流れに平行に支持して層流を乱さないようにすることが容易に可能になり、良好な成膜特性の実現が容易になる。

【００１９】そして、このように、支柱の先端部に平板や複数の枝を支持部として設ける場合には、サセプタの下面側に支柱の支持部を嵌め合わせる凹部を形成するとともに、該凹部の深さを支持部の厚みと一致させるようにすることにより、サセプタの下面側に凹凸部が生ぜず、サセプタの下面側が平坦になるので、層流の乱れが生じなくなり、良好な膜質を得ることができる。

【００２０】また、支柱を軸まわり回転駆動可能に形成すれば、成膜時にサセプタを回転駆動することができ、サセプタに装着された各基板上の膜厚の均一化、基板相互間の膜厚の均一化を容易に達成することができる。そして、支持手段を支柱とする場合、内管が構成する方形断面流路の厚み内に位置する支柱部分は、いずれの高さ位置でも、水平断面における差渡し寸法の最大値を２５mm以下とするようにすれば、サセプタ表面に乱流の影響を受けない基板装着領域を十分な広さに確保しつつサセプタの重量支持あるいは回転駆動に必要な強度を持たせることができる。

【００２１】また、支持手段を支持板とし、板面を鉛直方向としてサセプタの支持を支持板の側面で行うようにすれば、板面を流れと平行にし、かつ板面の上流側端部と下流側端部の水平断面形状を適宜に付与することにより、支持板を流れの中に置いても層流の乱れが生じなくなるので、サセプタを回転させる必要がないとき、支持板をサセプタの大きさ、重量に応じた枚数使用してサセプタの支持を容易に行い、かつ良質の膜を得ることができる。

【００２２】また、サセプタをサセプタの中心部で支持

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する支持手段は、サセプタ側先端部のサセプタ中心近傍に温度制御用センサが組み込まれたものとすれば、サセプタの裏面側に温度制御センサが組み込まれていた従来の装置と比較して、温度制御センサが基板により近くなり、基板温度の検出精度が上がり、膜質の制御が容易となる。

【００２３】

【実施例】図１に本発明による気相成長装置構成の第１の実施例を示す。この実施例は、サセプタを下方から支持する支持手段を支柱とした場合を示す。図中の符号は図６における同じ作用を持つものと対応させてある。また、図は、図６と同様、本発明に係わる要部のみを示したもので、反応炉より前段の原料ガス調整部分および段後のガス排気手段等は省略されている。反応炉容器４の一端に設けられた反応ガス入口５から供給される反応ガスは、流れ構成用の内管６により、被成膜基板１の下へと導かれる。被成膜基板１はサセプタ２に装着され、サセプタ２は、その中心部で下方から上下動可能な支柱１３により支えられている。サセプタ２の上方には、ヒータ３が設置されており、被成膜基板１およびサセプタ３を加熱することができる。

【００２４】反応炉容器４の上方側面には、被成膜基板を交換するために、被成膜基板あるいは被成膜基板を装着したサセプタを搬送するための搬送機構を内蔵した図示されていないロードロック室に連結するゲートバルブ１４が設けられている。支柱１３が上昇した状態で、ゲートバルブ１４を通して被成膜基板の交換を行い、あるいは未成膜の基板を装着したサセプタを支柱１３の上部に受け取ったのち下降して所定の位置まで移動し、成膜を行う。成膜位置では成膜面である基板の下面がほぼ上流側の内管の内部上面の延長面上にあって、反応ガスの層流が乱れを生じることなく基板の下を流れるようにしている。

【００２５】このように、支持手段を支柱とし、この支柱でサセプタを中心で支える装置構成とすれば、支柱を円柱または外周が円形の中空軸とすることにより、反応炉容器４内の気密を保持して支柱を軸まわりに回転駆動することが可能になり、これによりサセプタを回転させることが外部から容易に可能になるので、基板に形成される膜の膜厚を均一化することが容易になる。また、支柱を中空軸とすれば、先端部に温度制御センサを組み込んだとき、温度制御センサに到るリード線を中空軸内部を通すことができるので、温度制御センサのために装置が複雑化するのを避けることができる。

【００２６】図２にサセプタ支持手段の第２の実施例を示す。この実施例は、サセプタを回転させる必要がなく、かつ図１の場合よりもさらに支持手段の層流状態への影響を小さくしたい場合に好適な支持手段の一例を示したものである。支持手段は支柱として角柱１３を用い、角柱上端部に把持部１３ｄを設けてある。把持部１

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3dはコ字状に形成され、コ字の対向2辺の間にサセプタ2の下流側周縁部を把持する。把持部13dはサセプタの最下流側に位置しているので、上流側基板位置での層流に対する把持部13dの影響がなく、従って、サセプタの大きさや重量により、角柱13を複数本とすることも可能である。

【0027】図3はサセプタ支持手段の第3の実施例を示す。支持手段は支持板としてこれを2枚用い、板面を鉛直方向として板の側面でサセプタ2の周縁部を両側2個所で支持するようにしている。この支持方法では、支持板13のサセプタ2近傍はガス流の中に位置することになるが、支持板13が基板から十分離れておれば、基板面では層流状態が乱されず、膜質の低下は生じない。また、このような支持方法をとると、反応ガスの流れに平行にサセプタを支持する平行支持が容易に可能になり、少なくとも基板領域での層流状態のわずかな乱れ発生も防止するたとができる。また、この支持方法では、サセプタの傾斜支持も容易に可能となり、サセプタ2を流れに対して傾けて支持することにより、サセプタ2の上流側と下流側とで流速を変え、基板表面での上流側と下流側とで反応ガス成分の変化があった場合に生じうる膜厚不均一も容易に補償して均一化することができる。

【0028】さらに、この支持方法では、特に図示しないが、サセプタ2を回転可能とすることもできる。サセプタ周縁部に周方向の力を伝達するための機構として、例えば、電力量計式のトルク発生手段をサセプタ周縁部に配し、これを支持板13で支持することにより、周方向の力を非接触にサセプタ周縁部に伝達することができ、機械式に周方向の力を伝達する場合のように発塵のおそれがなく、また摩擦がないので、伝達される周方向力の経時変化もなく、サセプタの安定した回転動作と、安定した回転動作の長寿命化とが可能になる。そして、この場合の層流状態の維持は、周方向力の発生原理から、サセプタ表面と対向する磁極面をサセプタ表面から必要な寸法離した間隔で設けることができるので、問題なく可能である。なお、この支持方法では、支持板の支持面が滑動面となるので、摩擦係数が小さく、発塵量の少ない材質，例えば四弗化エチレンで覆った面とする。

【0029】図4にサセプタ支持手段の第4の実施例を示す。先に述べたように基板の成膜面に反応ガスを滑らかに流すことが極めて重要である。特にサセプタを回転する場合にはサセプタの回転面を平面に保つために，サセプタを支柱に直角に取りつけることが必要である。従ってサセプタと支柱との結合部を直角に保つための工夫が必要であり，例えば本実施例のように支柱13の頂部に直径20mm程度の円板13bを設け、一方サセプタ2にはこれと対応する形の凹部を設けてこれらの両者を嵌め合わせる方法が有効である。もちろん板の形状は円板に限らず平板であれば多角形でもなんでも良い。

【0030】図5は図4に示した実施例の変形例を示す

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ものであり、図のように、図4に示した支柱13の頂部の円板13bから13bと同じ平面内で複数本の枝13cを伸ばした構造とすれば、尚一層サセプタの安定化に効果がある。

【0031】

【発明の効果】本発明においては、気相成長装置を上述の構成としたので、以下に記載する効果が得られる。請求項1の装置では、被成膜基板が下面側に装着されるサセプタを下方から支持するようにしたので、サセプタを保持するのに、従来のような複雑精緻な保持機構が不要となり、サセプタの保持機構を極めて簡易に構成することができ、装置の信頼性が高まる。

【0032】請求項2の装置では、サセプタの上下動機構を別に設ける必要がなくなり、簡易な装置構成で被成膜基板の交換が可能になり、装置を自動運転に適した装置とすることが容易となり、かつ自動化した装置を安価に得ることができる。請求項3の装置では、サセプタ表面に広い基板装着領域を確保できるので、複数の基板を装着して同時処理が可能になり、装置の生産性が向上する。

【0033】請求項4の装置では、サセプタを反応ガスの流れに平行に保持する平行保持、あるいは反応ガスの流れに対して傾けて保持する傾斜保持が容易になり、良好な膜質，膜厚分布を得ることが容易になる。また、支持手段をサセプタの回転可能に構成することにより、上述した中心支持の効果と周縁部支持の効果との両効果を同時に得ることができる。

【0034】請求項5の装置では、サセプタの支持に必要な部材が低コストとなり、かつ保持機構も簡易化されるので、支持に必要なコストが従来の保持装置と比べて低減する。請求項6の装置では、サセプタを支持する支柱が先端部に広がりをもった平面を支持部として備えるので、層流状態を乱さないようにサセプタを支持することが容易に可能となり、装置として成膜性能の再現性が良好でかつ優れた膜質の膜を得ることができる。

【0035】請求項7の装置では、サセプタの下面側が平坦になるのでサセプタの下面側の層流に乱れが生ぜず、良好な膜質を得ることができる。請求項8の装置では、支柱が軸まわり回転駆動可能に形成されるので、支柱を介してサセプタを回転させることができ、これによって各基板上の膜厚均一化，基板相互間の膜厚の均一化の達成が容易になる。

【0036】請求項9の装置では、反応ガスの流れの中にある支柱部分を、そのいずれの高さ位置でも、水平断面における最大差渡し寸法25mm以下と、支柱の所要強度が維持できる範囲で細く形成したので、乱流の影響を受けない基板装着領域を広く確保することができ、基板の同時装着可能枚数が増し、装置を生産性の高い装置とすることができる。

【0037】請求項10の装置では、支持手段を支持板

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とするときに、サセプタの支持を、支持板の面を鉛直方向として支持板の側面で行うようにしたので、サセプタを回転させる必要がないときに支持板を流れに平行としてその上流側端部と下流側端部の水平断面形状を適宜に付与することにより、支持板がガス流中にあっても層流に乱れが生じなくなり、これにより、支持板をサセプタの大きさ，重量に応じた枚数使用してサセプタを容易に支持しつつ良質の膜を得ることができる。

【００３８】請求項１１の装置では、温度制御センサが支持手段先端部のサセプタ中心近傍に組み込まれるので、温度制御センサの位置が従来と比べて基板に近くなり、基板温度の検出精度が上がり、膜質の制御が容易となり、良質の膜を得ることが容易に可能になる。

【図面の簡単な説明】

【図１】本発明による気相成長装置構成の第１の実施例を示す縦断面図

【図２】本発明によるサセプタ支持手段の図１と異なる構造の一例をサセプタ支持手段の第２の実施例として示す斜視図

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【図３】本発明によるサセプタ支持手段の第３の実施例を示す斜視図

【図４】本発明によるサセプタ支持手段の第４の実施例を示す断面図

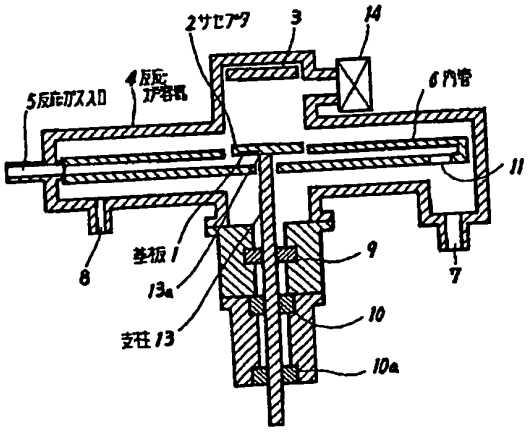
【図５】図４に示したサセプタ支持手段実施例の変形例を示すサセプタ下面図

【図６】従来の気相成長装置の構成例を示す図であって，同図（ａ）は縦断面図，同図（ｂ）は横断面図

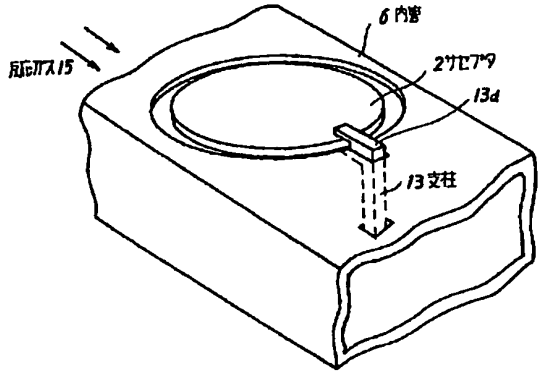
【符号の説明】

１　被成膜基板（基板）
２　サセプタ
４　反応炉容器
５　反応ガス入口
６　内管
１３　支持手段（支柱，支持板）
１３ｂ　円板
１３ｄ　枝
１５　反応ガス

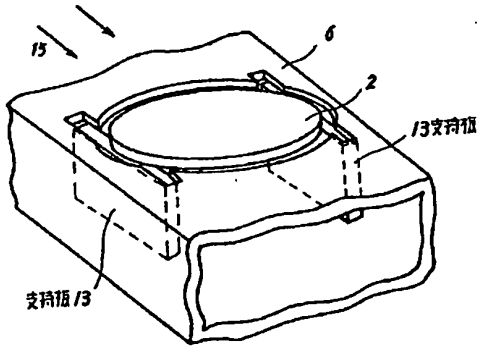
【図１】



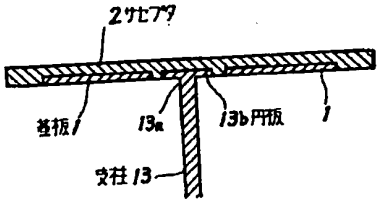
【図２】



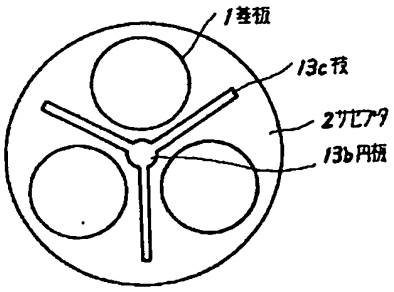
【図３】



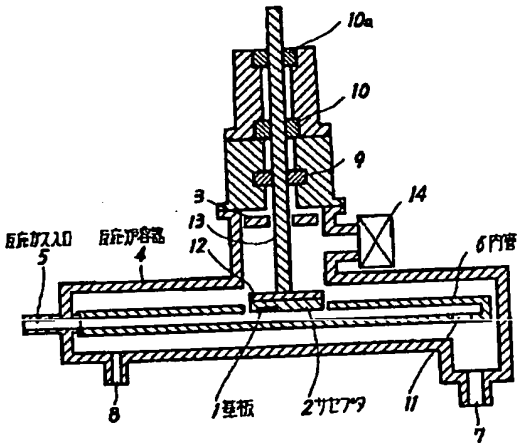
【図４】



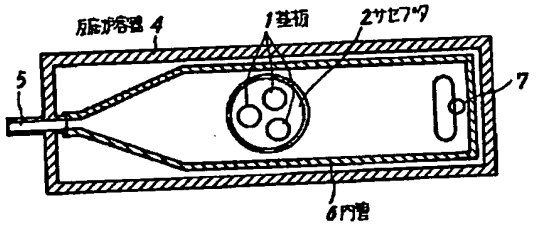
【図5】


1基板
13c枝
2サセプタ
13b円板

【図6】


10a
10
9
14
3
13
12
反応ガス入口
反応炉容器
5
4
6内管
8
1基板
2サセプタ
11
7

(a)


反応炉容器 4
1基板
2サセプタ
5
7
6内管

(b)